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BY LOUIS E. FRECHTLING

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BY their rapid offensives in Southeast Asia, the Japanese have not only wrested control of the Philippines, Malaya, almost all of the East Indies, and a large part of Burma from the United Nations, but now menace India and Australia. The Japanese navy, in command of far-flung bases in the Western Pacific and the Indian Ocean, also threatens to sever the shipping lanes which connect India and China with the Western powers. While the Allies' losses in men, matériel and strategic positions in the Far East have been great, their loss of essential raw materials may prove even more damaging to the war effort of the United Nations, and especially to that of their main arsenal, the United States. The Far East in recent years provided this country with over half its imports of crude materials and about a third of its imports of semi-manufactures, such as refined metals and vegetable oils.[1] It was practically the only source, foreign or domestic, of such important products as rubber, tin, silk,[2] manila hemp, kapok and quinine, and furnished significant amounts of other vital materials, including chromite, manganese, tungsten, sugar, coconut oil, copra, vegetable fibers and various drugs. The impact of Far Eastern losses is magnified by the fact that they coincide with rapidly expanding industrial activity in the United States, which requires constantly increasing amounts of raw materials. The United States must also release a portion of its supplies of scarce materials for shipment to other United Nations, especially Britain, to permit continued operation of their factories.

Realization that the American armament program has been hampered in the past and may be more seriously restricted in the future by lack of raw materials has come as a distinct shock to many citizens. They had been assured that the United States was the most self-sufficient of the great powers, the world's largest producer of aluminum, copper, iron ore, lead, molybdenum, zinc, coal, mica,[3] petroleum, phosphates, sulphur and cotton, and the second largest producer of bauxite, magnesite, wheat and wool.[4] As Germany expanded in Europe, and Japan in Asia, the American public found comfort in the belief that our unparalleled natural resources, coupled with our industrial system—the most powerful in the world—would automatically insure victory. This rationalization ignored the fact that a complex industrial economy depends on a wide range of raw materials, many of which are normally obtained from foreign sources.[5] The importance of rubber and tin imports was well known, but more obscure products, such as ferroalloys, kapok, cinchona bark and manila hemp, are almost equally essential for prosecuting the war. As the sources of these vital materials fall under the domination of the Axis, the position of the United States becomes progressively more difficult.

RAW MATERIAL PROGRAM

In the two decades preceding this conflict, a small group of officials and lay experts foresaw that raw material shortages would occur if the United States were involved in a major war. Although they urged that adequate preparation be made, especially through accumulation of reserves of scarce materials,[6] the first positive step in this direction was not taken until 1938, when the Navy Department was authorized by Congress to inaugurate a stock-

1. The continent of Asia in 1940 furnished 56.4 per cent of United States imports of crude materials and 33.4 per cent of semi-manufactures. The eastern part of the continent and India accounted for almost all of this trade, since exports from Western Asia are small. "Summary of the Foreign Trade of the United States—Calendar Year 1940," *International Reference Service*, December 1941, p. 47.

2. As in preceding years, crude rubber was the leading American import commodity in 1940; tin was the second most valuable import; and silk the fifth. *Ibid.*, p. 25.

3. The United States has not, however, produced significant amounts of "strategic" mica. See p. 86.

4. Eugene Staley, *Raw Materials in Peace and War* (New York, Council on Foreign Relations, 1937), pp. 14-15.

5. See the section on "Technology and the Raw Material Supply Area" in Eugene Staley, *World Economy in Transition* (New York, Council on Foreign Relations, 1939), pp. 22-35.

6. For recommendations of pre-war planning in the field of raw materials, see B. M. Baruch's report of December 24, 1919, in *American Industry in the War* (Washington, 1921), p. 9; report of a committee of the American Society of Metallurgical Engineers in *Elements of a National Mineral Policy* (New York, The Mineral Inquiry, 1933); Brooks Emeny, *The Strategy of Raw Materials* (New York, Macmillan, 1934), pp. 166-71; "Strategic and Critical Materials," Interim Report of the Committee on Military Affairs, House of Representatives, 77th Congress, 1st Session, *House Report No. 982* (Washington, 1941), p. 3.

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pile of strategic materials. An appropriation of $3,500,000 was made for this purpose in 1938, but only of $500,000 in each of the two succeeding years. Largely through the influence of the Interdepartmental Committee on Strategic Materials, headed by Herbert Feis of the State Department, a further step was taken in mid-1939 when Congress passed the Strategic Materials Act.[7] This Act provided that the Army and Navy Munitions Board should determine what supplies of strategic and critical materials[8] were needed, and recommend purchase of reserves to the Procurement Division of the Treasury, which would obtain them through commercial channels. Ten million dollars was made available for this program in 1939, and an additional $60,000,000 in 1940. At the same time, the Bureau of Mines and the Geological Survey were granted $500,000 annually to explore the United States and its territories for sources of scarce minerals and to develop methods for treating domestic low- and off-grade ores. The German conquest of Western Europe in mid-1940 spurred the government to enlarge drastically its defense program and to launch a more comprehensive and intensive attack on the raw material problem.[8a] The program changes constantly in response to domestic needs and foreign developments, but its outline remains substantially the same, involving (1) acquisition of stockpiles of scarce materials; (2) conservation of existing supplies; (3) development of hitherto untapped domestic and foreign sources, and (4) of substitutes for materials in short supply; and (5) use of supplies of scrap material.

Stockpiling. The Axis powers have relied on stockpiles of materials to carry them through periods of war emergency.[9] In their case, there were years of comparatively normal trade when reserves could be accumulated. By the time the United States embarked on its program, however, war conditions had already sent consumption of materials soaring, shut off sources of some products, and created a serious shipping problem. We were not able to build up stockpiles of commodities originating in the Far East in sufficient quantity to avoid potential shortages. Yet despite these handicaps, over a hundred commodities were stockpiled and substantial reserves of important materials, including rubber, manganese, tin and manila hemp, were acquired. At present, stockpiling activities are concentrated on commodities produced in areas threatened by the Axis—mica, manganese, shellac and burlap in India, graphite in Ceylon, wool in Australia, etc. The program is mapped out by various government agencies, principally the War Production Board,[10] and the actual purchases are made by subsidiaries of the Reconstruction Finance Corporation. The Metals Reserve Company buys metals and minerals; the Rubber Reserve Company, whatever rubber is available; and the Defense Supplies Corporation, a wide range of agricultural and animal products, including vegetable fibers, silk, wool, sugar and cork.[11] Since June 1940 these three agencies have expended $2,813,488,244 for essential materials.[12]

Conservation. The WPB and the Office of Price Administration direct a complex system of preference ratings and allocations designed to conserve scarce materials by restricting their consumption to essential military production.[13] This has resulted in severe curtailment of the output of motor cars, tires, metal products, clothing and many other items of civilian consumption. Even in the production of munitions and machines of war, the government is attempting to reduce the requirements of strategic materials. Specifications of industrial products have been altered to conserve resources of materials in short supply; the proportion of ferroalloys used in steel, for example, has been lowered.[14] As a further means of conservation, the President requested a "moral embargo" on the export of scarce materials shortly after war broke out in Europe. Since some traders would not voluntar-

7. Public Act, No. 117 (approved June 7, 1939), 76th Congress, 1st Session, *U.S. Statutes at Large*, Vol. 53, pp. 811-12

8. The Munitions Board had already defined these classifications. Strategic materials are "those essential to national defense, for the supply of which in war dependence must be placed in whole or in substantial part on sources outside the continental limits of the United States, and for which strict conservation and distribution control will be necessary." Critical materials are those whose procurement presents less of a problem than the strategic materials, "either because they have a lesser degree of essentiality or are obtainable in more adequate quantities from domestic sources, and for which some degree of conservation and distribution control will be necessary." The first published list of such commodities was *Strategical and Critical Materials—Their Relation to National Security* (September 1, 1938). Subsequent revisions were issued by the Munitions Board.

8a. See Public Act No. 664 (approved June 25, 1940), 76th Congress, 3rd Session, *U.S. Statutes at Large*, Vol. 54, pp. 572-74.

9. Antonin Basch, *The New Economic Warfare* (New York, Columbia University Press, 1941), pp. 124-50.

10. See below, p. 85.

11. For a summary of the activities of these RFC subsidiaries, see *House Report No. 982*, cited, pp. 5-11; "Report of the Secretary of Commerce Covering the War and Defense Activities of the Reconstruction Finance Corporation and its Subsidiaries, March 21, 1942," *Foreign Commerce Weekly*, March 28, 1942, pp. 6 ff.

12. Contracts for purchases of raw materials by RFC subsidiaries up to March 7, 1942: Metals Reserve Company, $2,215,818,000; Rubber Reserve Company, $292,000,000; Defense Supplies Corporation, $305,670,244. *Ibid.*

13. See M. A. Copeland, "Production Planning in War Economy," *Annals of the American Academy of Political and Social Sciences*," March 1942, pp. 103-104.

14. *Victory* (official bulletin of the agencies in the Office for Emergency Management, Washington), March 10, 1942, p. 8.

ily cease shipping rubber, tin and other products, the government assumed full supervision of exports under the Export Control Act of July 2, 1940.[15] Raw materials are released for shipment only to meet the urgent requirements of our Allies and other friendly countries.

New Sources. Since the United States possesses deposits of low-grade ores, such as manganese, chromite and tungsten, intensive efforts have been inaugurated to open up mines, develop new processes for treating the ores, and construct the plants required to concentrate and refine them.[16] Preference is given, wherever possible, to the establishment of domestic sources of supply, in view of the advantage of having materials close to fabricating plants and avoiding added strain on high-seas shipping.

Because of the demands of war, the United States is striving toward a much greater degree of self-sufficiency in many strategic minerals. But since some minerals, such as tin, are not known to exist in appreciable quantities within this country, we must look abroad for supplies. Also, many of the agricultural products formerly obtained from the Far East require climatic and soil conditions not present in the United States, but found in tropical areas of the Western Hemisphere. The Washington Administration is therefore greatly interested in developing the resources of Latin America to meet our needs. A broad program was outlined by the State Department and the Coordinator of Inter-American Affairs early in the war and rapidly expanded as the conflict drew closer to this continent. The Foreign Ministers of the American states recognized the importance of inter-American collaboration in this field when they met at Rio de Janeiro in January 1942.[17]

This objective is being achieved through a variety of measures. The United States has sent experts to survey the mineral and agricultural resources of Latin America, and advise local producers. Research and experimental stations have been established or planned, particularly in the tropical countries. Quasi-governmental organizations have been formed to produce commodities needed by the United States[18] and, through the Export-Import Bank, large amounts of American capital have been placed at the disposal of Latin American governments to finance production facilities.[19] Numerous agreements have been completed between the United States and the republics to the south whereby virtually all of their export surpluses of tin, tungsten, copper, rubber and vegetable fibers are purchased by this country.[20] Outside the Western Hemisphere, developmental activities are largely in British and Allied hands, although the United States is giving some assistance in the expansion of mineral production in central and southern Africa.

Substitution. With respect to materials now difficult or impossible to obtain from natural sources, substitution must be practiced. As an alternative to tin, silver can be used in solder and cadmium in bearing metals. Steel instead of brass may be employed in shell cases. Even more significant are the synthetic products made available by modern chemical research and engineering, and produced from basic substances available in this country. In some fields, much progress had been made before the war emergency. Synthetic fibers, such as rayon and nylon, are already manufactured in sufficient quantities to replace silk in many uses, and methods have been discovered to make various drugs from domestic materials, thereby reducing our dependence on imports. Contrary to general impression, many synthetic products are not inferior to the natural substances they replace. It should be remembered, however, that the manufacture of synthetic materials usually requires expensive and intricate machinery, the training of engineers and skilled workmen, and time to construct plants and bring them into large-scale production.

Salvage. The fifth method of meeting heavy demands for raw materials is the recovery of scrap, of which the United States possesses greater supplies than any other country. Industrial scrap has long been salvaged and valuable materials recovered, but more can be accomplished in this field. Recently the WPB embarked on a major campaign to bring in rubber, scrap iron and steel, other scrap metals, and rags from homes and farms.[21]

ORGANIZATION OF PROGRAM

The raw materials program is complex in organization, and its ramifications extend into many

15. Percy Bidwell, "Our Economic Warfare," *Foreign Affairs*, April 1942, pp. 422-23.

16. See "The Race for Metals," *Fortune*, March 1942, pp. 85 ff.

17. D. H. Popper, "The Rio de Janeiro Conference of 1942," *Foreign Policy Reports*, April 15, 1942.

18. The model for such organizations is the Société Haitiano-Americaine de Développement Agricole, organized in August 1941, with a board composed of three Haitians and three Americans. It will develop and grow vegetable fibers, rubber, and other products. See "Haitian Corporation Formed," *Agriculture in the Americas*, October 1941, p. 9; "Report from Haiti," *ibid.*, May 1942, pp. 87-90.

19. "Export-Import Loans to Latin America," *Foreign Policy Reports*, June 15, 1941.

20. See J. C. deWilde, "Wartime Economic Cooperation in the Americas," *Foreign Policy Reports*, February 15, 1942, and "Economic Projects for Hemisphere Development," *ibid.*, March 1, 1942; B. B. Goldner, "Latin American Strategic Metals and Their Relationship to the United States War Program," *Commercial Pan America*, March 1942.

21. *Victory*, February 10, 1942, p. 26; Mildred Adams, "Our Precious Junk," *The New York Times*, May 24, 1942.

areas of governmental and private activity. At least four government agencies have major roles in the program, and others play minor but important parts. The WPB, charged with directing the nation's war industries, determines the requirements of materials and their use in factories, and directs the production of raw materials within the country. With the OPA, it regulates the flow of commodities to industries for war production and civilian supply. The Board of Economic Warfare determines policy with respect to the procurement of raw materials for foreign sources, and supervises exports. Through its agents abroad, the State Department advises on the availability of materials, and acts as either an initiating agency or intermediary when trade agreements with foreign governments are under negotiation. None of the above-mentioned branches may actually expend money for the acquisition of raw materials or the development of resources except through the RFC or its subsidiaries. The activities of the various American bodies are coordinated with those of the British and other Allied governments through the Combined Raw Materials Board, which makes broad decisions on the development of supplies throughout the Allied world, and allocates materials between the United Nations.[22] Although the War Shipping Administration is not directly responsible, it is an important factor because it allocates the shipping space required to transport foreign products to this country.

The number of materials considered strategic or critical has increased considerably during recent months. In March 1940 the Army and Navy Munitions Board listed 14 products as strategic in nature, and 15 others as critical. It has since become apparent that many additional commodities are highly essential if the American industrial system is to operate with the greatest possible efficiency. The WPB issued on June 1, 1942 a report which listed 89 materials in short supply as "critically essential for the prosecution of the war" and unavailable for civilian industry. Eighty-two more were reported vital for the war effort, but sufficiently plentiful to allow limited amounts for necessary civilian consumption.[23] While a complete survey of United States supplies of these materials cannot be undertaken here, a group of scarce commodities which are especially significant in the procurement program have been selected for examination. All of them originate in areas either now under Tokyo's control or menaced by Japanese invasion.

22. For text of the announcement establishing the Board, see *Department of State Bulletin*, January 31, 1942, p. 87.

23. WPB, *Press Release, 1254*, June 1, 1942. Included in the list are some products which, strictly speaking, are not raw materials but semi-manufactures, e.g., chemical compounds.

MINERAL PRODUCTS[24]

Chromite. There is no satisfactory substitute for chromite, or chrome ore, in most of its uses. Ferrochromium, usually produced from metallurgical chromite (45 per cent chromic oxide and a chrome-iron ratio of 3 to 2), is used as a ferroalloy for making armor plate, stainless steel, high-speed cutting tools, and motor parts. Refractory-grade chromite (over 33 per cent chromic oxide) is employed in high-temperature furnace linings, and various grades of chromite are used in chemicals for tanning, electroplating, and other purposes. American imports of chromite reached 657,689 long tons in 1940, of which 24 per cent came from the Philippines. In addition, 6 per cent was obtained from the French island of New Caledonia, east of Australia, and 5 per cent from British India; both of the latter areas are threatened by Japan. The major part of American supplies originated in British Africa (43 per cent) and Turkey (11 per cent), but difficulties in securing shipping space for the bulky ores impair the value of these sources. American deposits of chromite are all low-grade, scattered and costly to exploit.[25] Consequently domestic production in recent years has been almost negligible, about 3,000 tons. Exploration by government geologists and financial incentives offered by the RFC have resulted in rapid expansion of chromite production, so that by the end of 1942 mines in the western states and Alaska are expected to reach an annual output of 420,000 tons of concentrates.[26]

Recent developments in the treatment of these ores have resulted in the discovery of practicable methods for transforming them into ferrochromium, or for using the inferior ores directly in the manufacture of steel alloys. While the cost will be high, the United States may achieve a large measure of self-sufficiency within a few years. Meanwhile, the output of several foreign producers is still available. Cuba, which exported 51,955 tons of refractory-grade chromite to the United States

24. Sources for commodity surveys include: Bureau of Mines, *Minerals Yearbook, Review of 1940* (Washington, Government Printing Office, 1941); Department of Agriculture, *Agricultural Statistics, 1941* (Washington, Government Printing Office, 1941); Tariff Commission, *Latin America as a Source of Strategic and Other Essential Materials*, Report No. 144, Second Series (Washington, Government Printing Office, 1941); Army and Navy Munitions Board, *The Strategic and Critical Materials* (March 1940); Emeny, *The Strategy of Raw Materials*, cited; statement of William L. Batt, chairman of the WPB Requirements Committee, and A. I. Henderson, Director of Materials, WPB, *Press Release 1278*, June 3, 1942.

25. American chromite contains from 35 to 42 per cent chromic oxide, while much of the imported ore contains 48 to 52 per cent. Geological Survey and Bureau of Mines, *Report upon Certain Deficient Strategic Minerals*, February 28, 1939 (reprinted November 1940), p. 11.

26. RFC, *Press Release 1593*, March 29, 1942.

in 1940, possesses substantial reserves, and has increased its shipments to this country to over 100,000 tons annually. Brazil has chromite deposits and exports small quantities of the ore—4,572 tons in 1940. The difficulty of getting the ore to tidewater and then to the United States, however, will probably prevent any great increase in shipments.[27]

Since the steel industry, with an annual output approaching 85,000,000 tons, accounts for 75 per cent of chromium consumption, American requirements have risen to about 900,000 tons a year.[27a] Imports of Latin American and South African ores will cover part of our needs for metallurgical chromite, and American consumers can draw on substantial stockpiles until domestic production is expanded.[28]

Manganese. Like chromium, manganese is one of the most vital strategic minerals, because about 12.5 pounds are needed to desulphurize and deoxidize every short ton of ordinary steel. There are several types of manganese-bearing ore, of which ferrograde is the most important. It contains at least 35 per cent, and preferably over 48 per cent, of manganese and is used to make the ferromanganese essential for steel production. The United States possesses adequate deposits of the lower-grade manganese ores, but has been dependent on foreign sources for 98 per cent (1940) of its ferrograde supplies. Imports in the latter category reached 1,282,079 long tons in 1940, of which the Philippines furnished 13 per cent and the U.S.S.R. 24 per cent. Both of these sources are now cut off, while transportation problems may prevent future shipments from British India, which furnished 15 per cent of our imports, and from the Gold Coast, which supplied 19 per cent.[29]

Although millions of tons of manganese metal are known to exist in this country,[30] the ores have not been extensively exploited because of the difficulties and high costs involved in processing them for use as ferromanganese. Before the present emergency, however, the development of methods for making ferromanganese from inferior ores had already reached an advanced stage, and with the encouragement of government loans and contracts, plants for treating domestic ores have been completed or are under construction. Altogether the Metals Reserve Company has let more than 50 contracts for manganese production in 13 states. Domestic output of high-grade concentrates is expected to reach 600,000 tons annually by mid-1943 and will increase later. Meanwhile, Latin American sources are still available. Cuba exported 130,646 tons of ore to the United States in 1940 (10 per cent of imports) and could send considerably more if shipping was not tight. Brazil, with large reserves in the states of Matto Grosso and Minas Geraes, furnished the United States with 168,241 tons in 1940, and could export perhaps twice that amount.

The American steel industry's requirements of manganese are now perhaps 1,300,000 tons a year, after allowing for economies achieved by lowering the metal content of manganese derivatives.[31] Despite this unprecedented demand, we have a stockpile, perhaps two years' supply, sufficient to cover our needs until domestic production is expanded. Imports from Latin America and Africa will presumably continue to arrive, but even without them no shortages are anticipated.

Mica. Unmanufactured mica is marketed in at least a hundred different forms, but the only categories of strategic interest are films, splittings and sheets, all of which are produced from block mica. Films and splittings are essential for the manufacture of electric motors, generators and transformers. Since the United States produces scarcely any of these grades of mica, it has been dependent on imports, which amounted to 7,386,387 pounds in 1940. British India supplied 90 per cent of the total, and small amounts were received from the French island of Madagascar and from Canada. With respect to sheet mica, used in radio and magneto condensers, spark plugs and radio tubes, the United States is somewhat better situated, producing about 20 per cent of requirements and relying on India for most of the remainder. Threats to the safety of India have led the American government to develop alternate supplies.

Mining of block mica in the United States has been encouraged and imports from Mexico and Brazil have increased. The sorting, trimming and preparation of the crude substance to produce the thin films and splittings offers more of a problem. India's predominance in the mica field was based not only on plentiful supplies of the basic material, but also on the abundance of cheap labor which could be trained in this highly skilled work. In recent months, however, an extensive splitting in-

27. "Brazil's Chromite Production," *Foreign Commerce Weekly*, January 31, 1942.

27a. WPB, *Press Release 1278*, cited.

28. See Arthur Kemp, "Chromium: A Strategic Material," *Harvard Business Review*, Winter 1941, pp. 199-212.

29. See table, p. 92.

30. In the Chamberlain field of South Dakota, it is estimated that 102,000,000 tons of manganese may be present, but it is found in crude material containing less than one per cent of the metal. *Report upon Certain Deficient Strategic Materials*, cited, p. 4.

31. A committee of experts reported in 1940 that lower-grade ores could be substituted for at least 20 per cent of the requirements of ferromanganese, and another 20 per cent saved by changing steel-plant operating practices and substituting other metals for manganese alloys. *Minerals Yearbook, Review of 1940*, cited, p. 569.

dustry has been started in the United States, as well as in Mexico and Brazil and, if necessary, Western Hemisphere production could meet most of our needs. Recent British operations in Madagascar, when completed, will assure the United Nations of an alternate source of mica.[32]

Tin. Normally about 40 per cent of the tin consumed in the United States is used in making tin plate for food, oil, and other containers. Tin also enters into the manufacture of solder and into the production of metal alloys used for bearings in many types of machinery.[33] Annual consumption in the past has been about 80,000 long tons of primary tin, almost all of which originated in Southeast Asia. The Japanese now control territories which produced 67 per cent of the world's tin in 1940, leaving only Bolivia and other scattered sources to the United Nations.[34] American tin output is small, confined almost entirely to Alaska, and is apparently incapable of appreciable increase.[35]

America's vulnerability in tin supply led the Navy to embark on the acquisition of a stockpile in 1938, which was carried forward under the agreement of June 28, 1940 between the Metals Reserve Company and the International Tin Committee. At the end of 1941 government stocks were about 40,000 tons, and additional reserves in private hands were estimated at 100,000 tons.[36] Soon thereafter Japanese conquests shut off shipments. Turning to a safer and closer source of supply, the Metals Reserve Company negotiated a contract with Bolivian tin producers on November 4, 1940, providing for the annual purchase of 18,000 tons (metal content) of tin concentrates. Subsequent arrangements were made to buy the entire export surplus of Bolivian tin, except for the output of the Patiño mines, which is pledged to Britain.

Energetic measures are being taken to raise production through replacement and the use of more mining machinery. The shortage of labor presents a more serious problem, for only a limited number of Bolivians are able to work in the mines, located 12,000 to 15,000 feet above sea level.[37] Some gains may be made by raising the metal content of the concentrates through the introduction of improved methods of processing the ore.[38] Since the United States has had no tin-smelting industry since 1923, it was planned in mid-1940 to build a plant in this country to refine Bolivian concentrates. After long investigation and negotiation, a contract was signed in February 1941 between the Defense Plants Corporation and a Dutch firm to construct a smelter in Texas. The plant opened in April 1942, with a capacity of 21,600 tons of fine tin from ores brought from Southeast Asia and 30,000 tons from the lower-grade Bolivian product. It is readily capable of expansion to 50,000 tons annually.[39] The higher potential capacity of the smelter suggests that concentrates may be brought to the United States from Nigeria or the Belgian Congo.[40]

America's annual consumption of 80,000 tons of tin has probably been lowered to 60,000 tons by conservation measures. These include replacing tinplate containers with glass, plastic, or other materials, and making the tin coating thinner.[41] Cadmium, of which the Allies control two-thirds of the world's production, can be substituted for tin in solders and bearing metals. More attention is being given to secondary or reclaimed tin. Recently the WPB has encouraged the collection and detinning of used tin cans, by which it is estimated that a maximum of 3,750 tons can be obtained annually.[42] There are definite limitations to the output of secondary tin, however, for the cost of detinning plants is high, and the amount of scrap decreases as less virgin tin is used. The situation of the United States tin supply causes much concern, for Bolivian mines will probably provide only a third of the quantity formerly received from Southeast Asia, and we will have to draw continually on reserves. An appreciable rise in African production may, however, eventually ease the shortage.

Tungsten. The principal use of tungsten, either in ferroalloy form or tungsten carbide, is in the manufacture of high-speed tools and hard-faced

32. The United States received three shipments of mica from Madagascar when the island was under Vichy domination.

33. In peacetime, tin plate accounted for 41 per cent of tin consumption; solder, 22; babbitt metal, 8; bronze, 7; collapsible tubes, 4; and galvanizing, type metal, terne-plate and chemicals, each about 2 per cent, Army and Navy Munitions Board, *The Strategic and Critical Materials*, cited, p. 18.

34. See table, p. 92.

35. *Minerals Yearbook, Review of 1940*, cited, pp. 672-73; *Report upon Certain Deficient Strategic Minerals*, cited, pp. 25-30.

36. Estimate by Hilda Austern, "America's Tin Problem," *Amerasia*, February 1942, pp. 551-52. Other observers place the total reserves as low as 115,000 tons; *The New York Times*, March 1, 1942.

37. "Mineral Resources, Production, and Trade of Bolivia," *Foreign Minerals Quarterly*, October 1939, p. 62; "Non-Pacific Tin," *The Economist*, January 17, 1942, p. 84.

38. As high as 40 per cent of the metal is lost in the processes now in use. "Mineral Resources, Production, and Trade of Bolivia," cited, pp. 21-24.

39. "Report of the Secretary of Commerce, March 21, 1942," cited.

40. A production drive in Africa promises to raise the annual output of the Belgian Congo to 20,000 tons, and of Nigeria to 17,000 tons within a year. "Non-Pacific Tin," cited.

41. The WPB's Conservation Order M-81 was expected to reduce consumption of tin by the canning industry from 40,000 tons in 1941 to 24,500 in 1942. *Victory*, February 17, 1942, p. 6. Further deductions are expected soon. See WPB, *Press Release 1033*, May 4, 1942, and *T-429*, June 8, 1942.

42. WPB, *Press Release 1223*, June 1, 1942.

machine parts. It imparts to the materials with which it is alloyed the property of remaining hard even when red hot. Smaller quantities are used in electric lamp and radio tube filaments and electric contact points. In the armament industry, tungsten is employed to make armor-piercing bullets, linings of heavy guns, armor plate, and gun breeches. As in the case of other minerals, the United States has extensive tungsten deposits, but since domestic ores are costly, the country has depended on foreign sources for about half its requirements. In 1940 imports of tungsten ores and concentrates amounted to 5,414 short tons (gross weight), of which China furnished 46 per cent, and Thailand and Burma 2 per cent each. These supplies are now shut off, and Australian shipments, amounting to 6 per cent more, are endangered.

Through the encouragement given to producers by the RFC, domestic production is expected to rise from 5,319 tons of ores and concentrates (60 per cent tungsten oxide) in 1940 to an annual rate of 19,500 tons by the end of this year.[43] Imports from Latin America amounted to about 2,200 tons in 1940, have subsequently increased, and could supplant the sources lost in the Far East. The expansion of output has been accomplished largely through agreements concluded by the Metals Reserve Company with Bolivia, Argentina, Peru and Mexico, providing for purchase of their entire export surpluses. Exports from Bolivia may reach 4,000 tons, and from Argentina 3,000 tons. With a small stockpile on hand to carry the country through the next few months, we should be able to cover our requirements of about 12,000 tons annually.[44]

Other Minerals. The United States formerly obtained two-thirds of its *antimony* from China but, as Japanese aggression cut off Chinese shipments, our principal suppliers became the Latin American countries, with Mexico and Bolivia in the lead. The RFC has contracted for the entire output of Mexico and Bolivia, and smaller quantities are received from Peru, Argentina and Chile, while limited domestic production in Idaho is expected. American suppliers of *crystalline graphite,* required in some types of foundry crucibles, have been obtained largely from Ceylon and Madagascar. Apprehension over loss of these sources was partially relieved when the British landed on the latter island.

AGRICULTURAL AND PASTORAL PRODUCTS

Fats and Oils. Our annual requirements of all types of vegetable and animal fats and oils in pre-war years were about 10 billion pounds. These materials were consumed as food (66.9 per cent in 1940), soap (20.2 per cent), and in various industrial uses, such as paints and inks (12.9 per cent).[45] Roughly 10 per cent of our needs were met by exports of the Far Eastern areas now held by Japan. Ninety-eight per cent of United States imports of copra, the dried meat of the coconut, was provided by the Philippine Islands and the Netherlands Indies (600,601,000 pounds in 1940), and over 99 per cent of coconut oil by the Philippines (370,683,000). The Dutch archipelago also supplied about 80 per cent (180,243,000 pounds) of our purchases of palm oil, a semi-solid fat obtained from the fruit of the oil palm. Substitution for these products will be difficult, for they have a high lauric acid and glycerine content, making them exceptionally desirable in the production of soap and glycerine, a vital material in the manufacture of dynamite and cordite. Another essential use of palm oil is in the making of tin plate.

Comparatively small supplies of copra in Ceylon, Australasia and East Africa, and larger amounts of palm oil in British West Africa are as yet untouched by the Axis. Britain will need these, however, to bolster its own diminishing imports. Fortunately, fats and oils are widely interchangeable, and the United States will be able to replace a large part of its export trade by increasing production of cotton seed, peanut oil, soybean oil, and animal fats. Elsewhere in the Americas, Brazil has a likely substitute for the coconut palm in the babassu nut, whose kernels have a high glycerine content. Exports of babassu nuts to the United States amounted to 98,272,000 pounds in 1940 and may be raised if transportation facilities in the jungle are improved and more labor made available for harvesting and cracking the kernels.[46] Argentina could also provide large quantities of flaxseed and linseed oil.[47]

Although an over-all shortage of fats and oils in the United States is not anticipated in the near future, experts warn that Far Eastern losses, combined with higher industrial requirements and large lease-lend shipments to Britain and the U.S.S.R., may present a distinct problem within a year. Perhaps even sooner, restrictions will be made in domestic consumption of soap and edible fats.[48]

43. RFC, *Press Release 1593,* cited.

44. "The Race for Metals," cited, p. 126; "America's Tungsten Supplies," *The Economist,* December 13, 1941, pp. 1719-20; *New York Herald Tribune,* February 10, 1942.

45. "Fats and Oils," *Fortune,* April 1942, pp. 68 ff.

46. Potentially, Brazil could produce 380 billion pounds of oil from existing trees. "Fats and Oils," cited, p. 70.

47. Sixty-three per cent of Argentina's flaxseed exports went to European markets in 1937. Shipments to the United States might increase if vessels were available. *Latin America as a Source of Strategic Materials,* pp. 289-96.

Quinine. Medicinal quinine is prepared from the bark of various species of cinchona trees and is used widely in tropical and semi-tropical regions for prevention and treatment of malaria. Before the war, American consumption of quinine was about 4,000,000 ounces annually but, with Army forces and workmen stationed in malarial zones on four continents, our requirements may easily have increased 300 to 500 per cent. The Dutch island of Java was the source of about 90 per cent of the world's cinchona bark exports, and of almost all our imports. Latin America is the most promising potential producing area left to the United Nations. Brazil has shipped small quantities of bark from wild trees, and experimental plantings are under way in Guatemala and other Caribbean countries. The prevalent labor shortage, however, and the slow growth of the cinchona tree—at least five years must elapse between planting and first harvest[49]—prevent any substantial increase in plantation production in the near future. Meanwhile, it is expected that bark from wild trees will soon yield 2,000,000 to 3,000,000 ounces of quinine a year. At the end of 1941 government stockpiles and private reserves of quinine amounted to some 10,000,000 ounces. As these may be exhausted within a year, increasing reliance must be placed on the synthetic anti-malarial drugs, atabrine[50] and plasmoquine. Disagreement exists in medical circles as to whether they may be used with complete safety. Subsequent research may result in improvements.

Rubber. Undoubtedly the most serious shortage which confronts all the United Nations and particularly the United States is in rubber. When the Japanese swept over Malaysia, they seized areas which accounted for 780,820 long tons, or 98 per cent of our imports and 90 per cent of the world's production of crude rubber in 1940.[51] This was a severe blow to the American industrial system, which has been increasing its consumption of rubber from 582,000 tons in 1939 to 766,000 tons in 1941. A major portion of the rubber factories' output now goes into machines of war—tires for combat and transport vehicles and for planes, tank treads, gun mounts, etc.[52] While priority must be accorded to purely military needs, it is also essential that tires be provided for 4,000,000 commercial vehicles and the 20,000,000 private automobiles which must be kept running to avoid serious disruption of our economic system.[53] Besides meeting our own needs, we must supply a bare minimum of 198,750 tons to Britain, the U.S.S.R., and other anti-Axis nations who now possess scant reserves and small sources of rubber supply.

To meet the crisis presented by the impending rubber shortage, a mobilization program has been improvised in Washington, largely in the six months following Pearl Harbor, which exceeds in complexity, speed, and cost of materials and labor any similar development in America's history. It involves the expenditure of roughly a billion dollars for synthetic rubber plants, with the nation's oil wells and refineries, coal mines and grain fields providing the raw materials. It includes the sowing of guayule in northern Mexico and our own Southwest, the gathering of wild rubber in many parts of Latin America, and the establishment of numerous plantations in the tropical portions of the Western Hemisphere. If and when all the projects come into operation, the Americas will produce more rubber than did the entire world before the war.

The government is placing most reliance on the output of the synthetic rubber plants now under construction or planned. They can be fed with basic materials found in this country and they offer the surest method of reaching large-scale production in the shortest possible time. It is now planned to construct facilities with an annual output of 1,000,000 long tons, of which 900,000 will be Buna-type rubber, and the rest divided between Butyl and Neoprene. Originally developed in Germany, Buna-S rubber is a polymerization, i.e., a linking of the molecules, of about 75 per cent butadiene and 25 per cent styrene. The principal intermediate substance, butadiene, can be made from petroleum via refinery gases, coal and limestone via acetylene, or from a wide range of agricultural products, such as grain, potatoes, and sugar via alcohol. As the United States has a plentiful oil production, petroleum will be used to make most of the butadiene, but alcohol has recently been included, apparently in response to pressure from farm interests. The styrene is derived from coal tar or petroleum. The advantages of Buna-S are that chemists have some experience in producing it, and that it is the best of the synthetics for tire manufacture. Butyl, a new discovery of the Standard Oil Company (New Jersey), appears to be simpler to make from refinery gases, uses cheaper materials,

48. Karl Brandt, "Mobilizing Our Dormant Resources for Total War," *Foreign Affairs*, April 1942, pp. 438-49; "Fats and Oils," cited.

49. Wilson Popenoe, "Quinine from the 'Fever Tree,'" *Agriculture in the Americas*, March 1942, pp. 43-47.

50. The production of atabrine, a German discovery, is being greatly increased by American patent-holders, who have also made the process available to other firms. *The New York Times*, March 25, April 11, 1942.

51. See table of world production, p. 92.

52. A Flying Fortress requires 1,250 pounds of rubber; a battleship, 150,000 pounds; a tank, 1,750 pounds; a 10-ton pontoon bridge, 3,200 pounds; and a half-ton truck, 125 pounds. OEM, *Press Release PM-3390*, May 22, 1942.

53. Estimate of C. L. Dearing, *Automobile Transportation in the War Effort* (Washington, Brookings Institution, 1942), Pamphlet No. 37, pp. 4-25.

and is formed in a continuous process, but it has yet to pass extensive testing. Neoprene, a good specialty rubber, does not lend itself to mass production because it is costly to make and requires materials now in short supply.[54] The construction of synthetic plants is a complicated job and takes 15 to 18 months even under high pressure. Therefore, anticipated output this year is only 25,000 to 40,000 tons, rising to 300,000 or possibly 350,000 tons in 1943, and perhaps 600,000 to 700,000 tons the following year. By the end of 1944, all the planned facilities should be in operation. Subsequent developments in production methods may increase these estimates, but they cannot be relied on.

The government actually embarked on the expansion of natural rubber production in Latin America before the synthetic program was launched, but the former has been relegated to a secondary position since it did not promise an adequate supply. In July 1940 the Department of Agriculture, working in conjunction with private American interests and Latin American officials, intensified its experimental development of disease-resisting and prolific strains of *Hevea brasiliensis,* best of the rubber-producing trees. These activities have reached an advanced stage and planting materials have been furnished to eleven countries.[55] Inasmuch as *Hevea* trees need at least six years to reach maturity, and the recruitment of workers to tend the plantations is an acute problem, the yield is not expected to reach 50,000 tons before 1950. The need for immediate supplies has turned attention to the rubber trees growing wild in Latin America—*Castilloa* in Mexico, Central America, Colombia and Ecuador, and *Hevea* in Brazil, Bolivia, Peru and Venezuela. The government has been slow in organizing a production drive through which natives could be provided with implements for gathering the rubber, sent into the jungle, and encouraged to sell their output to local American buyers, but progress is now being made. With an adequate organization, the United States may get 75,000 to 150,000 tons annually from this source alone. Guayule, a desert shrub which grows wild in Mexico and has been cultivated in southern California, has a rubber content as high as 22 per cent of its weight and can be harvested a year after planting, although 4 to 7 years' growth produces much more. Much doubt exists over guayule's potentialities and the government is counting on only 1,000 tons of domestic rubber and perhaps 10,000 tons from Mexico in 1944.[56] The importance of Latin American rubber should not, however, be overlooked. The natural material is required, at the present stage of technology, for mixing with Buna-S to make the best tires. Quantitatively, Latin American rubber will meet from 10 to 15 per cent of our needs during the next few years.

A stockpile of Far Eastern crude rubber, amounting to 693,000 tons at the beginning of this year, will help supply our fabricating plants until synthetic materials become available. The WPB plans to draw 196,500 tons from reserves this year and expects to receive 434,000 tons in imports—cargoes on the high seas before the Japanese took Malaysia, and smaller quantities from Latin America, Ceylon and Africa. Requirements are placed at 306,750 tons for the production of American and lease-lend matériel, 198,750 tons for shipments to our Allies, and 150,000 tons for domestic civilian consumption. The latter allotment will be reduced to 123,750 tons in 1943 and 1944, as contrasted with an average annual requirement of 600,000 tons before the war.[57] Since all the rubber earmarked for civilian use will be needed by buses, trucks and the cars of defense workers, rigid conservation measures are being introduced, and no new tires are in prospect for average car operators before 1944. If large amounts of old rubber are salvaged in the current campaign, sufficient reclaimed material may be available to retread civilian tires. The capacity of existing reclaim plants, however, is only 350,000 tons a year.

CONCLUSION

America's supplies of vital raw materials formerly obtained in the Far East are fully expected to become more critical in the coming months as the demands of war industry continue to rise.[58] The stockpiles are sufficient in many cases to last through 1942 or even longer, but thereafter we must depend on the output of new sources or on substitutes—both those already in commercial production and those which scientists may develop. Research in Germany during the last war and in the

54. "Rubber: How Do We Stand?" *Fortune,* June 1942, pp. 92 ff.; "Synthetic Rubber Hits a Million," *Business Week,* May 30, 1942, pp. 15-16. Many other methods of producing synthetic rubber have been proposed in recent weeks, but it is considered extremely doubtful that they are superior to the processes now already known.

55. See articles in *Agriculture in the Americas,* especially: J. J. Blandin, "Why Rubber Is Coming Home," May 1941, pp. 1-10; L. G. Polhamus, "War Speeds the Rubber Project," February 1942, pp. 29-31; "The Rubber War," May 1942, pp. 82 ff.; and E. N. Bressman, "Rubber Production in the Western Hemisphere," *Inter-American Quarterly* (Washington), January 1941, pp. 52-60.

56. See Ruth Ringle, "Rubber from Western Weeds," *Survey Graphic,* February 1942, pp. 72-78; and a less optimistic report by E. W. Brandes, "Go Ahead, Guayule," *Agriculture in the Americas,* May 1942, pp. 83-86.

57. See statement of Leon Henderson before the Senate Committee Investigating National Defense Activities, *OPA Press Release PM-2625,* March 5, 1942.

58. See statement of William L. Batt, chairman of the Requirements Committee of WPB, and A. I. Henderson, Director of Materials; OEM, *Press Release PM-3390,* May 22, 1942.

period leading to the present conflict made that country remarkably independent of outside sources of strategic materials. American chemists may make similar advances. We cannot, however, afford to rely on future discoveries, so a major portion of our activity must be directed toward expanding the output of mines, factories, and fields in the United States and Latin America according to conventional production methods. Moreover, the United States still has much to learn in the conservation of materials by curtailing unnecessary consumption, and in the collection and use of scrap supplies.

The success of the materials mobilization program depends on the vision, determination, and effectiveness of the agencies directing it and on the degree of cooperation given by industry and the general public. The nation as a whole, in fact, must assume a large part of the burden of responsibility for the critical situation which exists today. As long as a substantial majority of the people were reluctant to take an active part in the war or to make adequate preparations for large-scale participation, it was as difficult to build up proper reserves of materials as it was to prepare the armed forces. While war raged in Europe and Asia, most economic activity in the United States continued to operate within the framework of the free enterprise system, which meant that considerations of cost rather than of national security determined where we obtained raw materials.

Once the rearmament program got under way, some specific factors retarding the mobilization of raw materials became apparent. There was failure on the part of the production planning agencies to compile up-to-date estimates of requirements of materials, making it impossible to anticipate intelligently the needs of armament factories.[59] This difficulty has been recognized, and the WPB has recently overhauled its requirements and allocations system. Lack of foresight by government officials is evident in the "prodigal liberality" with which huge quantities of precious materials were removed from the nation's stockpiles and used in the production of consumers' goods.[60] Related to this factor was a reluctance in official circles, especially the National Defense Advisory Commission, and later the OPM and Supply Priorities and Allocations Board, to curtail normal operations in industry during 1940 and 1941 and to begin immediate conversion for war production. Although we are fighting a total war, it is evident that special interests — sectional, industrial, commercial, etc. — still compete for relative advantage in carrying forward the materials program. This is especially obvious in the rivalry between various war agencies, between interested corporations, and between industry and agriculture for a share in the synthetic rubber scheme.[61] Full and effective production to assure victory demands a moratorium on competition except as it speeds the war effort.

The procurement program was further impeded by faulty organization within the government. The NDAC and its successors should have assumed responsibility for the stockpiling program but, as they failed to act, the State Department and later the Board of Economic Warfare[62] initiated plans for the purchase of strategic materials. Overlapping authority led to duplication of activity and differences between the various branches.[63] Once a decision was reached, the next problem was to convince the RFC and its subsidiaries, the only organizations authorized to allocate public funds, that the expenditure was desirable. The RFC group, dominated by men of conservative financial views, were concerned first with making expenditures which would prove good investments rather than with building up stockpiles of vital materials, whatever their price might be.[64] These conflicts have to a large extent been adjusted by the Executive Orders of April 13 and May 21,[65] which define more specifically the functions of the respective agencies. The WPB now determines requirements and organizes their production in this country. In the foreign field, the State Department supervises negotiations with other governments and maintains general direction over commercial relations. Subject to this limitation, the BEW has explicit powers to organize procurement operations abroad. The Presidential orders also provide that the RFC is to make funds available when requested by the proper agency. Generally speaking, the division of responsibility is much sharper than before, and coordination may be achieved through liaison committees, especially the full Board of Economic Warfare. It should be noted, however, that all foreign procurement in World War I was directed by one agency, the War Trade Board,[66] and that the British in the present war have centralized procurement activities in a Ministry of Supply.

59. Eliot Janeway, "Trials and Errors," *Fortune*, June 1942, pp. 204-208; Copeland, "Production Planning for a War Economy," cited, p. 102.

60. Bidwell, "Our Economic Warfare," cited, p. 431.

61. "Rubber: Where Do We Stand?" cited.

62. Created as the Economic Defense Board on July 30, 1941, this agency's title was changed to Board of Economic Warfare on December 17, 1941.

63. See a strong condemnation of this feature of governmental organization in *House Report No. 982*, cited, p. 26.

64. Michael Straight, "Jesse Jones: Bottleneck," *New Republic*, December 29, 1941; Dwight MacDonald, "Jesse Jones, Reluctant Dragon," *Nation*, February 14, 1942, pp. 189-90; Eliot Janeway, "Why Are We Short of Tin?" *Asia*, May 1942, p. 260.

65. For text of Executive Order No. 9128, see *Federal Register* (April 15, 1942), Vol. 6, pp. 2809-10; and clarification and interpretation of this Order, *ibid.* (May 23, 1942), Vol. 7, p. 3843.

66. H. J. Tobin and Percy Bidwell, *Mobilizing Civilian America* (New York, Council on Foreign Relations, 1940), pp. 212-14.

World Production of Selected Strategic Materials

By Ona K. D. Ringwood and Louis E. Frechtling

THE importance of each major producing area in the world's output of certain vital raw materials is shown in the tables below. The years selected are the latest for which reasonably complete statistics are available. It will be noted that the countries over which the Japanese now exercise control accounted for appreciable proportions of these materials, and that other significant Asiatic producers indicated in the tables are among those whose trade with the Allies is menaced by the Axis.

Production of Crude Rubber, 1940

	Long tons	*Per cent*
British Malaya	540,417	38.9
North Borneo and Sarawak	52,789	3.8
Thailand	43,940	3.2
Indo-China	64,437	4.6
Netherlands Indies	536,740	38.6
Philippines and Oceania	2,267	0.2
Ceylon	88,894	6.4
India	11,510	0.8
Burma	9,668	0.7
Africa	17,326	1.2
South America	17,601	1.3
Mexico (guayule)	4,106	0.3
TOTAL	1,389,695	100.0

Production of Tungsten Ores, 1938*

	Short tons	*Per cent*
China	14,756	40.1
Burma	6,982	18.9
Portugal	3,097	8.4
United States	3,043	8.3
Bolivia	2,788	7.7
Argentina	1,317	3.6
Others	4,800	13.0
TOTAL	36,783	100.0

*In terms of concentrates containing 60 per cent of tungsten trioxide. *Latin America as a Source of Strategic Materials*, p. 171.

Production of Cinchona Bark, 1938*

	1,000 pounds	*Per cent*
Netherlands Indies	24,665	85.7
British India	1,984	6.9
Bolivia (exports)	1,950	6.8
Others	187	0.6
TOTAL	28,786	100.0

**Latin America as a Source of Strategic Materials*, p. 237. Statistics are for principal producing countries only.

Production of Manganese Ore, 1938*

	Metric tons	*Per cent*
Japan	75,000†	1.5
Philippine Islands (exports)	49,359	0.9
British Malaya	32,483	0.6
British India	983,464	19.3
U.S.S.R.	2,272,800	44.5
Gold Coast (exports)	329,411	6.5
Union of South Africa	551,739	10.8
Egypt	153,112	3.0
Cuba	123,844	2.4
Brazil	221,961	4.3
Others	313,827	6.2
TOTAL	5,107,000	100.0

*Ore containing varying proportions of manganese metal above 30 per cent. *Minerals Yearbook, Review of 1940*, p. 584.

†Estimate.

Production of Tin (Metal Content), 1940*

	Long tons	*Per cent*
British Malaya	85,384	36.9
Netherlands Indies	44,447	19.2
Thailand	17,447	7.5
Indo-China	1,560	0.7
Burma	5,500†	2.4
Australia	3,500†	1.5
China	6,349	2.7
Bolivia	37,923	16.3
Argentina	1,600†	0.7
Belgian Congo	7,600†	3.3
Nigeria	12,012	5.2
United Kingdom	1,800	0.8
Others	6,578	2.8
TOTAL	231,700	100.0

**Minerals Yearbook, Review of 1940*, p. 683.

†Estimate.

Production of Crude Chromite, 1939*

	Metric tons	*Per cent*
Philippine Islands (exports)	126,749	10.9
New Caledonia	52,000	4.5
British India	49,925	4.3
Turkey	191,644	16.4
Union of South Africa	160,014	13.7
Southern Rhodesia	139,083	11.9
Cuba	67,061	5.7
Others (largely U.S.S.R.)	380,524	32.6
TOTAL	1,167,000	100.0

**Minerals Yearbook, Review of 1940*, p. 593.

In the July 1 issue of FOREIGN POLICY REPORTS*:*
MACHINERY OF COLLABORATION BETWEEN UNITED NATIONS *by Payson S. Wild*